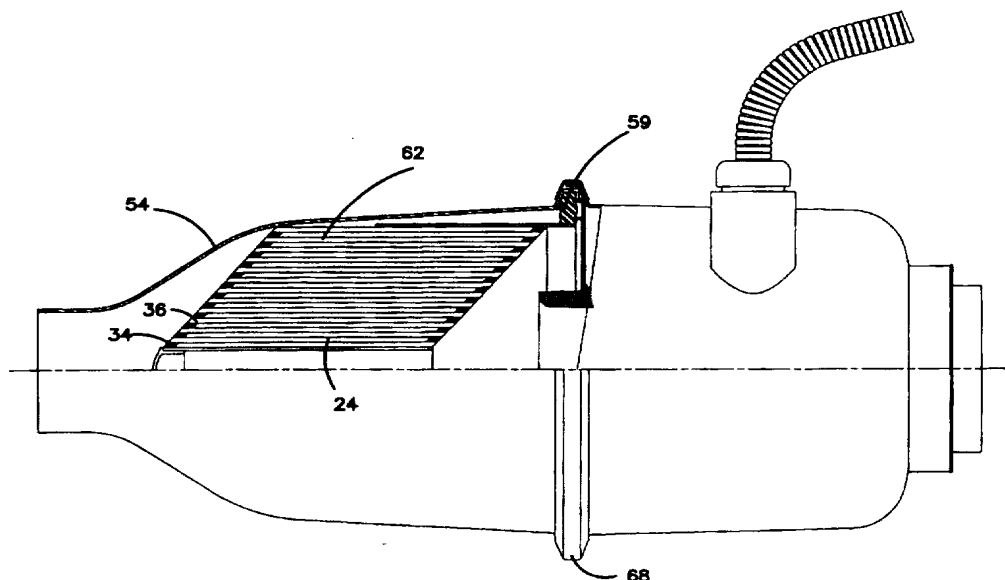




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<b>(21) International Application Number:</b> PCT/US97/06935 <b>(22) International Filing Date:</b> 25 April 1997 (25.04.97) <b>(30) Priority Data:</b> 08/638,703                      26 April 1996 (26.04.96)                      US <b>(71) Applicant:</b> DONALDSON COMPANY, INC. [US/US]; 1400 West 94th Street, Minneapolis, MN 55440-1299 (US). <b>(72) Inventors:</b> TOKAR, Joseph, C.; 6205 137th Street, Apple Valley, MN 55124 (US). GILLINGHAM, Gary, R.; 17305 Flemming Lane, Prior Lake, MN 55372 (US). WAGNER, Wayne, M.; 120 Redwood Drive, Apple Valley, MN 55124 (US). RISCH, Daniel, T.; 1116 136th Street West, Burnsville, MN 55337 (US). ROTHMAN, Jim, C.; 332 Riverwoods Lane, Burnsville, MN 55337 (US). WAHLQUIST, Fred, H.; 8444 11th Avenue South, Bloomington, MN 55420 (US). STEINBRUECK, Edward, A.; 16671 N. Hillcrest Court, Eden Prairie, MN 55346 (US). CARTER, Steven, A.; 4847 Sheffield Circle, Eagan, MN 55122 (US). <b>(74) Agent:</b> BRUESS, Steven, C.; Merchant, Gould, Smith, Edell, Welter & Schmidt, 3100 Norwest Center, 90 South Seventh Street, Minneapolis, MN 55402 (US).		<b>(81) Designated States:</b> AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

**(54) Title:** CONICAL FILTER**(57) Abstract**

A conical filter device inserts into a duct having flow passing from upstream to downstream. The filter device includes fluted filter media (62) having flutes formed therein and a housing (54). The filter forms a seal (59) between the outer edge of the filter at the downstream side and the housing. The upstream face of the filter is conical-shaped in a first embodiment and frusto-conical in a second embodiment with the housing roughly corresponding to the shape of the filter. The filter elements (62) are formed by winding layers of filter media to form a circular cross-section. The elements are moved axially as they are wound or placed on a shaping form while the sealant is still pliable to shape the element.

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## CONICAL FILTER

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a conical filter and in particular to a conical  
5 filter of fluted filter media for placement inline in a fluid stream, and a method for making the filter.

#### 2. Description of the Prior Art

Fluid filters are used for a wide variety of applications. Fluid filters typically use a filter element inside of a housing having an inlet and an outlet so that the fluid  
10 passes through the filter media, thereby trapping particulate material. Aerodynamic conical filters are generally used for high velocity fluid flow applications, such as automobile air intake filters. In the past there has been little usage of conical filters mainly due to problems with size and effectiveness. Generally, these filters have used pleated filter media. With the pleated filters, straight through flow is not possible.

15 This causes high pressure differentials across the filter and flow distribution problems.

To combat these problems, designers have generally increased the spacing between the pleats, thereby reducing the density of the filter media. This has reduced the effective life of the filters and has not solved the flow distribution problem. These filters have also had the added problem in that the filter media is not self supporting.

20 Generally, rigid housings are required for use of these filters.

Another shortcoming with typical prior filter designs is unequal flow distribution. Flow is often directed to a center portion of filters, thereby loading the filter unevenly. Portions of the filter may load over a much shorter interval, thereby requiring replacement of the filter element. However, if flow were directed more  
25 evenly over the entire filter, loading would be more uniform and more gradual, so that the filter life is extended.

An example of a conical filter is shown in U.S. Patent No. 5,106,397, issued to Ford Motor Company, April 21, 1992. In this patent, a pleated filter is used to filter air to an engine. To force air through the media, the top of each pleat is sealed together so  
30 that air cannot escape through gaps in the media. This allows an opening between each pleat for air to enter and flow down the pleat, through the media and out the inside center of the filter. In order to avoid restricting the incoming air, the pleats must

be spaced, thus limiting the amount of filtering media available for filtering. An increase in filtering media results in an increase in pressure differential across the filter. Furthermore, for the air to enter the filtering media, it must make a sharp directional turn so as to pass through the filter media, thereby increasing the pressure drop across the filter.

It can be seen then, that an improved conical filter is needed which provides for increased filtering area without an accompanying high pressure differential across the filter. Such a filter should also provide for improved flow distribution and even loading over the entire filter. The present invention addresses these as well as other problems associated with conical filters.

### **SUMMARY OF THE INVENTION**

The present invention is directed to a conical filter and in particular to a conical filter formed of fluted filtering media.

In a preferred embodiment of the invention, the permeable filter media used in the filter has corrugated sheets of filtering material sealed to sheets of filtering media at alternating ends, forming filtering flutes, which can be rolled into a conical shape. The alternating ends of each flute are sealed off such that the fluid enters through the dirty side of the flute and is forced through to the clean side such that the particulate material is deposited onto the filtering media.

In a conical filter, the filter media is coiled in a spiraling configuration about a center winding portion, forming an upstream face and a downstream face, such that the filtering flutes are substantially parallel to the incoming fluid flow. This allows the dirty fluid to enter the filter media without making an abrupt directional change and, hence, reduces the pressure differential across the filter media. Moreover, because the fluid is allowed to enter the filtering media without making an abrupt directional change, it is not necessary to have spaces in between the filtering flutes as is necessary with pleated filters. Therefore, the present arrangement allows for a maximum filtering area for a given volume without a corresponding increase in pressure differential currently associated with the prior art devices and also increases the life of the filter element.

Another advantage of the conical shape is the distribution of particulate across the filter. As the incoming dirty fluid hits the bullet-shaped face of the conical filter, the flow is pushed from the inner to the outer portion of the filter media such that the fluid flow across all portions of the filter is relatively even. This distribution of  
5 particulate further increases the filtering effectiveness and the effective life of the filter element.

The inline capability provides for a reduction in space with greater media filtering area over presently used filter elements and housings.

The present invention also includes methods for making the conical filter.  
10 According to a first method, the filter is made by providing a strip of fluted filter media having the plurality of fluted compartments formed therein. The filter media is then coiled about a mandrel. While the media is being coiled about the mandrel, a bead of sealant is applied to adjacent layers of the coil, thereby, closing off alternate sections of the fluted material. Before the sealant hardens, the coiled filter media is placed on a  
15 conical forming tool. By forcing the coiled filter media onto the conical forming tool, the center portion of the media is extruded longitudinally to form a conical filter face. The filter is then allowed to cool to a hardened state. According to a second method, the filter media is wound in a spiral, forming a conical filter face as the filter media is wound and the sealing bead is applied.

20 It can be appreciated that with the present invention, an increased filtering area can be accomplished without an accompanying increase in pressure differential. Because of this, the present filter can accept higher fluid flows and has a longer effective life.

These features of novelty and various other advantages which characterize the  
25 invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which there is illustrated and described a preferred embodiment of the invention.

**BRIEF DESCRIPTION OF THE DRAWINGS**

In the drawings, wherein like reference letters and numerals indicate corresponding elements throughout the several views:

Figure 1 shows a perspective view of fluted filter media for the filter apparatus according to the principles of the present invention;

Figures 2A-2B show diagrammatic views of the process of manufacturing the filter media shown in Figure 1;

Figure 3 shows a detail perspective view of a layer of filter media for a filter according to the principles of the present invention;

Figure 4 shows a perspective view of the fluted filter media spiraled in a cylindrical configuration according to the principles of the present invention;

Figure 5 shows a detail perspective view of a portion of the spiraled fluted filter media for the filter element shown in Figure 4;

Figure 6 shows a side elevational view of a first method of forming a conical filter element on a conical forming support;

Figure 7 shows a second method of forming a conical filter element;

Figure 8 shows a side elevational view of a conical filter according to the principles of the present invention;

Figure 9 shows a side elevational view of the conical filter shown in Figure 8 in combination with a filter housing;

Figure 10 shows a side elevational view of an alternate embodiment of the invention wherein the filter is encased in its own housing and can be inserted inline in a fluid flow;

Figure 11 shows a side elevational view of a further alternate embodiment of the present invention including a flow distribution vane;

Figure 12 shows a fluid velocity profile across the conical filter;

Figure 13 shows a side view of an alternate embodiment of the present invention showing a frusto-conical filter; and

Figure 14 shows a side partial sectional view of the filter shown in Figure 13 and an associated housing.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring now to the drawings, and in particular to Figure 1, there is shown a portion of a layer of permeable fluted filter media, generally designated 22. The fluted filter media 22 includes a multiplicity of flutes 24 which form a modified corrugated-type material. The flute chambers 24 are formed by a center fluting sheet 30 forming alternating peaks 26 and troughs 28 mounted between facing sheets 32, including a first facing sheet 32A and a second facing sheet 32B. The troughs 28 and peaks 26 divide the flutes into an upper row and lower row. In the configuration shown in Figure 1, the upper flutes form flute chambers 36 closed at the downstream end, while upstream closed end flutes 34 are the lower row of flute chambers. The fluted chambers 34 are closed by first end bead 38 filling a portion of the upstream end of the flute between the fluting sheet 30 and the second facing sheet 32B. Similarly, a second end bead 40 closes the downstream end 36 of alternating flutes 24. Adhesive tacks connect the peaks 26 and troughs 28 of the flutes 24 to the facing sheets 32A and 32B. The flutes 24 and end beads 38 and 40 provide a filter element 22 which is structurally self-supporting without a housing.

During use, unfiltered fluid enters the flute chambers 36 which have their upstream ends open as indicated by the shaded arrows. Upon entering the flute chambers 36, the unfiltered fluid flow is closed off by the second end bead 40. Therefore, the fluid is forced to proceed through the fluting sheet 30 or face sheets 32. As the unfiltered fluid passes through the fluting sheet 30 or face sheets 32, the fluid is filtered as indicated by the unshaded arrow. The fluid is then free to pass through the flute chambers 34, which have their upstream end closed and to flow through the downstream end out the filter media 22. With the configuration shown, the unfiltered fluid can filter through the fluted sheet 30, the upper facing sheet 32A or lower facing sheet 32B, and into a flute chamber 34 blocked on its upstream side.

Referring now to Figures 2A-2B, the manufacturing process for fluted filter media which may be rolled to form filter elements, as explained hereinafter, is shown. It can be appreciated that when the filter media is spiraled, with adjacent layers contacting one another, only one facing sheet 32 is required as it can serve as the top for one fluted layer and the bottom sheet for another fluted layer. Therefore, it can be appreciated that the fluted sheet 30 need be applied to only one facing sheet 32.

As shown in Figure 2A, a first filtering media sheet is delivered from a series of rollers to a crimping roller 44 forming a nip with a second opposed roller 45. In a similar manner, a second sheet 32 is fed to the rollers 44 and 45. A sealant applicator 47 applies a sealant 46 along the upper surface of the second sheet 32 prior to engagement between the crimping roller 44 and the opposed roller 45. As shown in Figure 2B, the first sheet 30 engages the corrugated surface of the roller 44, and as it is pressed between the opposed roller 45, takes on a corrugated or fluted configuration matching that of the corrugated roller 44. The troughs 28 have a sealant applied at their apex or are otherwise welded to the facing sheet 32 to form flute chambers 34.

10 The sealant 46 forms first end bead 38 between the fluted sheet 30 and the facing sheet 32. The resultant structure of the facing sheet 32 sealed at one edge to the fluted sheet 30 is the layerable filter media 48, shown in Figure 3.

When forming a conical filter, a filter media spiral, as shown in Figure 4 is formed. It can be appreciated that the filter media layer 48 having a single backing sheet 32 and a single end bead 38 shown in Figure 3 can be wound to form a spiral-type cylindrical filter element, generally designated 52, shown in Figure 4 and shown in greater detail in Figure 5. To form the spiral filter element 52, a bead of sealant is applied lengthwise on a mandrel 54. An end of the single sided fluted filter media 48 is secured to the mandrel 54 via the bead of sealant. The single sided fluted filter media 48 is then rolled onto the mandrel 54 as a second end bead 40 along a second edge of the filter media is applied with the sealant applicator 47 to the pleated side of the single sided fluted filter media 48, as shown in Figure 4. As the pleated filter media 22 is rolled onto the mandrel 54, the second end bead 40 adheres to the first facing sheet 32 of the single sided fluted filter media 48, as shown in Figure 3. It can be appreciated that when the filter media is wound onto the mandrel, with adjacent layers contacting and sealing peaks and troughs of flutes, only one facing sheet is required as it serves as the top layer for one flute and the bottom layer for another flute.

Therefore, as the second end bead 40 adheres to the first facing sheet 32 the downstream closed end flute 36 for the filter media spiral 52 is formed. When the required length of single sided fluted filter media 48 is rolled onto the mandrel 54 such that the diameter of the filter media spiral 52 is as required, an outer sealing bead is applied to the free end of the single sided fluted filter media 48. The free end of the

pleated filter media is then secured to the facing sheet 32 such that the free end adheres to the filter media spiral 52.

The filter media is configured so that when filtering, dirty fluid, as indicated by the shaded arrows, enters the upstream open ended flute chambers 36 which have their upstream ends open. After entering the upstream open ended flute chambers 36, the unfiltered fluid engages the second end bead 40. Therefore, the fluid is forced to proceed through the fluting sheet 30. As the unfiltered fluid passes through the fluting sheet 30, the fluid is filtered as indicated by the unshaded arrow. The fluid is then free to pass through the downstream open end flute chambers 34, which have their upstream end closed, and out the filter media 48. In addition, the unfiltered fluid can filter through the facing sheet 32 to the chambers 34.

The conical filters can be made by several manufacturing techniques. While the sealant on the filter media spiral is still warm and pliable, the filter is somewhat moldable. In a first method, at this stage, the filter media spiral 52 is pressed against a conical forming tool 96, as shown in Figure 6, such that the filter media spiral 52 forms a conical shaped element 62. The conical filter media spiral 52 is then allowed to remain on the conical forming tool until it reaches a hardened state and is therefore rigid. The conical filter element 62 is then removed from the conical forming tool 96 and may be fitted with gasket seals 59.

It can be appreciated that the conical filter may also be made by the method shown in Figure 7, wherein single-sided fluted filter media 48 is rolled onto a mandrel 54. With the second manufacturing method, the mandrel moves axially relative to the sealant applicator 47. This causes the layer of single-sided filter media 48 to wind in a spiraling configuration. The second end bead 40 is deposited by the sealant applicator which is held steady as the mandrel 54 and the already-wound filter media move axially. In this manner, the second end bead 40 is at the leading face of the conical filter 62 which spirals outward to form a conical face. The second bead 40 seals the adjacent layers of peaks and troughs of flutes so that only a single facing sheet 32 is required, as it serves as the top of one layer and the bottom of the next. It can be appreciated that the mandrel may be held axially stationary; however, this requires that both the sealant applicator 47 and the feed of the single-sided fluted filter media 48 move axially relative to the mandrel so that a conical filter is formed.

Referring now to Figure 8, there is shown a first embodiment of a conical filter 60 having a conical filter element 62. The conical filter 60 includes an outer skin for filter housing 58 and a center plug 66. The filter 60 includes single sided fluted filter media 48, which is wound around the center plug 66. It can be appreciated that the center plug 66 may be the mandrel upon which the filter media is wound, or if the mandrel has been removed, the center orifice may have a cap or cover. The filter element 62 has preferably been formed into a conical shape by the methods described above. The single sided fluted filter media 48 has alternating upstream closed end flutes 34 and upstream opened end flutes 36, as previously shown in Figures 1 and 5. Viewing from the downstream side, there are alternating downstream closed end flutes 36 and downstream opened end flutes 34. In a preferred embodiment, the outer covering for the filter housing 58 includes gaskets 59, for placement of the filter element 62 into a housing 54.

Fluid cleaner housing 54, shown in Figure 9, is an existing housing for automotive air filtering purposes. Preferably, the cleaner housing 54 is constructed out of molded plastic. The filter 60 is inserted into the inlet end of the cleaner housing 54. The filter 60 is held in place by a compression ring 68 which seals the gasket 59 between the upstream and downstream sections of the cleaner housing 54.

As the flow enters the cleaner housing 54, the conical shape of the upstream face of the filter 60 forces the fluid from the inside of the conical filter 60 towards the periphery of the face of the filter 60. This results in relatively even fluid flow distribution across the filter. This is accomplished without abrupt directional changes which also decreases pressure differential across the filter over the prior art. After the flow passes through the filter 60, it exits on the downstream side of the filter 60 and passes through the downstream side of the cleaner housing 54. More particularly, as the flow approaches the filter 60, it enters through an upstream open end flute 36. As the flow passes through the upstream opened end flute 36, it is forced by the downstream closed end of flute 36 to pass through the wall of the flute 36 into a downstream open ended flute 34. Particulate material which had been carried into the upstream opened end flute 36 will be deposited on the inside wall of the upstream opened end flute 36.

An alternate preferred embodiment of the filter 70 is shown in Figure 10. The embodiment shown in Figure 10 has the filter 60 in a stand-alone housing 78. This embodiment is configured so that it can be adapted to other existing inline filter applications. More particularly, the stand alone housing 78, which is preferably  
5 constructed of molded plastic, is fitted with an inlet neck 92 and an outlet neck 94 so that the stand alone housing 78 can be fitted inline in a fluid stream.

Another alternate embodiment of the present invention, generally designated 80, is shown in Figure 11. A circular or annular vane or baffle 82 is placed at the inlet opening of the filter housing 54. It can be appreciated that the vane 82 provides for  
10 increased fluid flow at the outermost regions of the conical filter element 62, thereby providing even distribution of fluid flow across the entire conical filter element 62. This embodiment, therefore provides for more even distribution of particulate and more uniform particulate loading. Hence, the filter element achieves an extended life.

Referring now to Figures 13 and 14, there is shown a further embodiment of a  
15 filter according to the present invention, generally designated 100. The filter 100 includes a frusto-conical shaped filter media element 102 and an associated filter housing 104. The filter media element 102 includes an upstream face 100 which gives the filter media 102 a frusto-conical configuration. The upstream face 110 includes a central planar portion 112 and an annular outer sloping portion 114. The sloping outer  
20 portion is configured to slope outward and away from the central planar portion which is substantially transverse to the prevailing upstream flow. In addition, the filter media may include a downstream gasket 116 which is configured to seal against the side of the housing 104. It can be appreciated that although the filter 100 includes a frusto-conical filter media 102, the methods for making the filter remain unchanged for those  
25 shown in Figures 7 and 8. The filter media 102 may be placed on a frusto-conical form, while the sealant is still soft, to impart a frusto-conical shape. Alternatively, the filter media 102 may be wound with the mandrel remaining axially stationary for the first portion of the winding to provide the planar upstream central face 112 and then move axially during winding at the outer portion to provide the outer sloping portion  
30 of 114.

As shown in Figure 14, the housing 104 includes a substantially straight housing wall 106. The straight wall 106 provides improved capacity for the filter

housing volume. It can be appreciated that with the wall 106 extending substantially parallel to the filter flutes and the prevailing direction of the flow, the wasted space between the outward sloping wall 106 and the outer portion of the filter is minimized.

In the embodiment shown in Figure 14, the housing 104 includes an upstream portion 120 and a downstream portion 122. The gasket 116 of the filter media forms a downstream seal between the housing wall 106 and the filter media 102. The housing 104 also includes an inlet portion 124 adapting to an upstream duct in an outlet portion 126 leading down to the downstream ductwork.

Referring now to Figure 12, there is shown a velocity profile graph across the conical filter 80, shown in Figure 11. Figure 12 shows the varying exit velocities of the fluid flow, represented along the Y-axis, in relation to the fluid flow's position as it exits the filter, represented along the X-axis. As is evidenced by the graph, fluid flow across a conical filter of this type has a relatively uniform velocity profile providing the improvements and advantages described herein.

It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

**WE CLAIM:**

What is claimed is:

1. A filter having flow passing from upstream to downstream through the  
5 filter, comprising:  
filter media comprising a plurality of flutes, wherein each flute defines  
a fluted chamber extending in a longitudinal direction;  
wherein the filter media is coiled in a spiraling configuration having an  
outer surface and an upstream and a downstream face; and wherein a portion of  
10 the upstream face of the coil slopes outward and downstream.
2. A filter according to claim 1, further comprising a duct receiving the  
filter, wherein the outer surface forms a seal with the duct.
- 15 3. A filter according to claim 1, wherein first ends of the flutes extend to  
the upstream face and second ends of the flutes extend to the downstream face.
4. A filter according to claim 3, wherein alternating ends of the flutes are  
closed.  
20
5. A filter according to claim 1, wherein the filter comprises a  
substantially frusto-conical filter having a substantially planar center portion at  
an upstream side and an outer portion sloping away from the planar center  
portion.  
25
6. A filter according to claim 5, wherein the outer portion slopes away  
from the planar portion at an angle of about 50 degrees.
7. A filter according to claim 5, wherein the outer portion slopes outward  
30 and downstream from the planar center portion.

8. A filter according to claim 1, wherein the center portion of the upstream face has a substantially conical configuration.
9. A filter having flow passing from upstream to downstream through the filter, comprising:  
5 a cylindrical filter housing including an upstream end portion of decreased diameter;  
filter media comprising a plurality of flutes, each flute defining fluted compartments extending in a longitudinal direction, wherein one end of each compartment is closed, and wherein the closed ends of the compartments are  
10 on alternating opposite ends;  
wherein the filter media is coiled in a spiraling configuration about a center portion, forming an upstream face and a downstream face, wherein the coil of filter media includes an outer edge forming a seal with the housing; and  
15 wherein a center portion of one face of the coil extends longitudinally in a substantially conical configuration.
10. A filter according to claim 9, further comprising a center mandrel, wherein the coil of filter media is wound about the center mandrel.  
20
11. A filter according to claim 9, further comprising flow directing means for spreading the flow radially outward over the filter.
12. A filter according to claim 11, wherein the flow directing means  
25 comprises a circular vane in the filter housing upstream of the filter media.
13. A filter according to claim 9, wherein the filter housing includes a side wall extending substantially parallel with the axis of the cylindrical filter housing.  
30
14. A method of making a filter element, comprising the steps of:

providing a strip of fluted filter media having a plurality of fluted compartments formed therein;

coiling the filter media about a mandrel;

sealing adjacent layers of the coil; and,

5 extruding a center portion axially to form a conical filter face.

15. A method of making a filter according to claim 14, wherein the center portion is extruded by forcing the coiled filter media onto a conical-shaped forming tool.

10

16. A method according to claim 14, wherein the fluted filter media comprises a corrugated type material and a facing sheet tacked together and a continuous first end bead at a first edge strip, thereby forming a strip of fluted filter media having a plurality of fluted compartments formed therein.

15

17. A method according to claim 16, wherein a first sheet of filter media is delivered to a crimping roller, and a second sheet is supplied to an opposed roller, and wherein sealant is applied along the upper surface of the second sheet prior to engagement between the crimping roller and its opposed roller such that the second sheet is bonded to the corrugated sheet.

20

18. A method according to claim 16, wherein a second end bead is applied to a second edge of the pleated side of the strip of pleated filter media while the filter media is wound onto the mandrel.

25

19. A method according to claim 14, wherein a spiral filter is sealed with a heated sealant, and wherein the center portion of the spiral filter is extruded before the sealant is solidifies.

30 20. A method according to claim 19, wherein the spiral filter media is formed by placing the spiral filter onto a conical shaped forming tool before the sealant solidifies.

21. A method according to claim 20, wherein the spiral filter with the center portion extruded is allowed to cool following placement on the forming tool such that it forms a conical shaped spiral filter.
- 5 22. A method according to claim 14, wherein the mandrel moves axially relative to the strip of fluted filter media while being coiled.
- 10 23. A method according to claim 14, wherein the strip of fluted filter media moves axially relative to the mandrel while being coiled.
- 15 24. A method of making a filter element, comprising the steps of:  
providing a strip of fluted filter media having a plurality of fluted compartments formed therein;  
coiling the filter media about a mandrel;  
sealing adjacent layers of the coil; and  
wherein the mandrel and strip of fluted filter material move axially relative to one another , thereby forming a conical filter face.

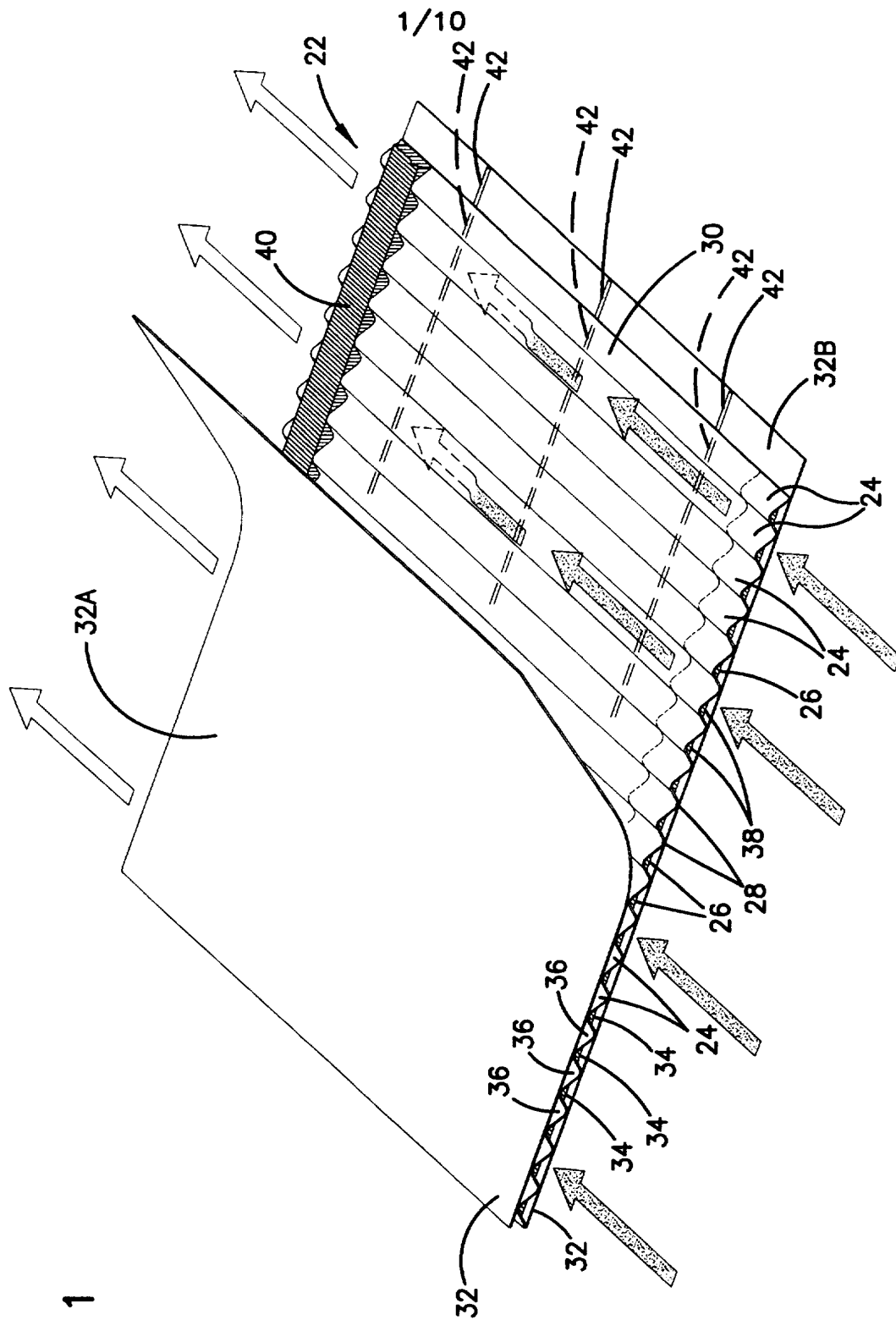
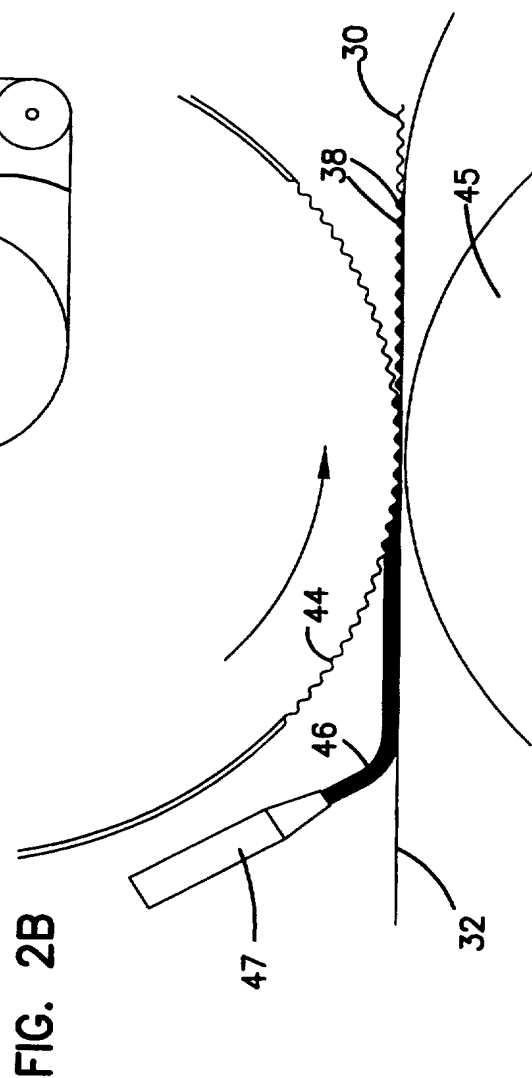
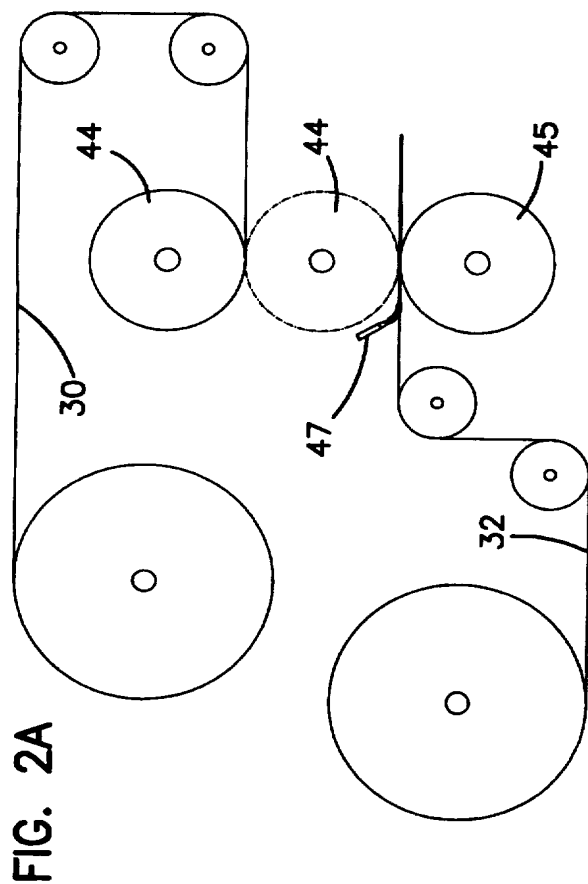
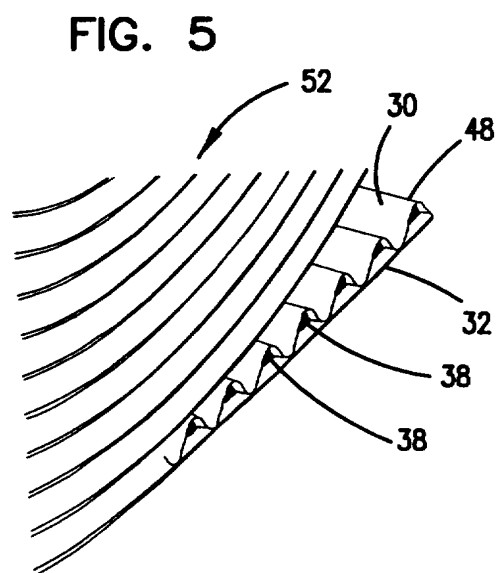
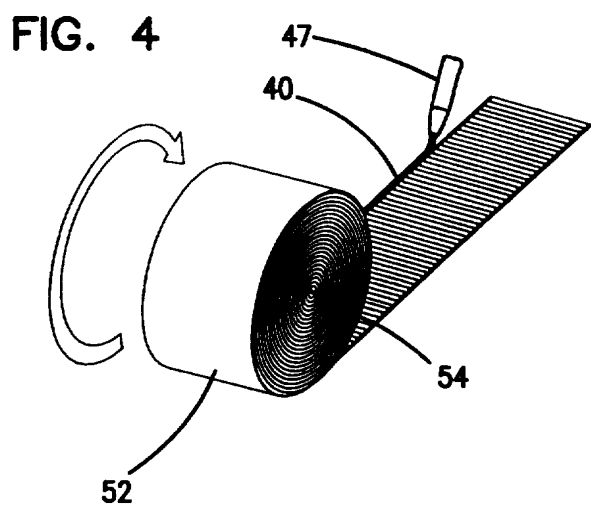
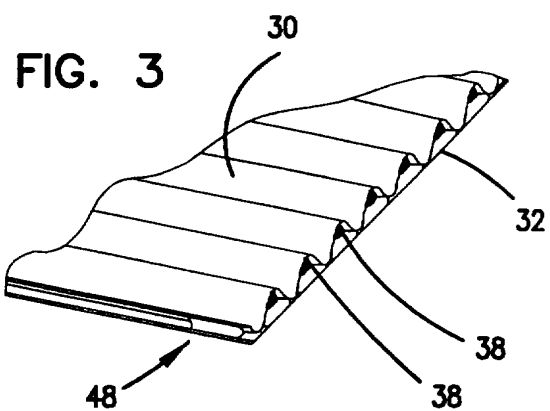


FIG. 1





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FIG. 6

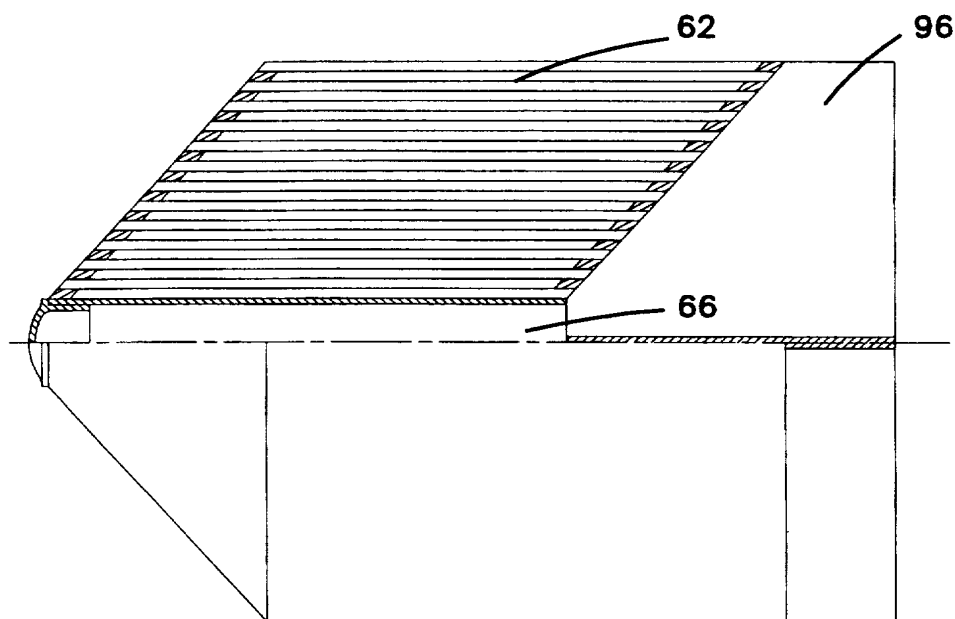
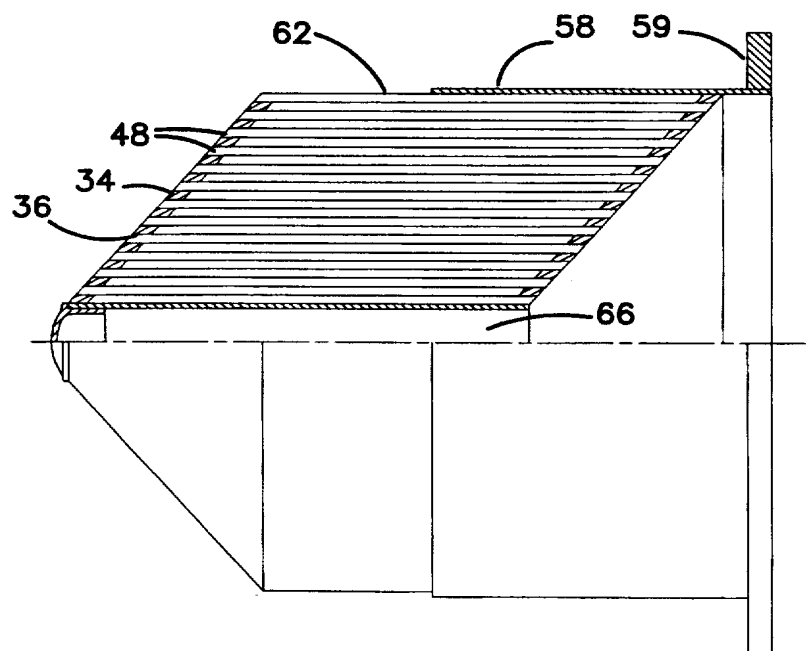


FIG. 8



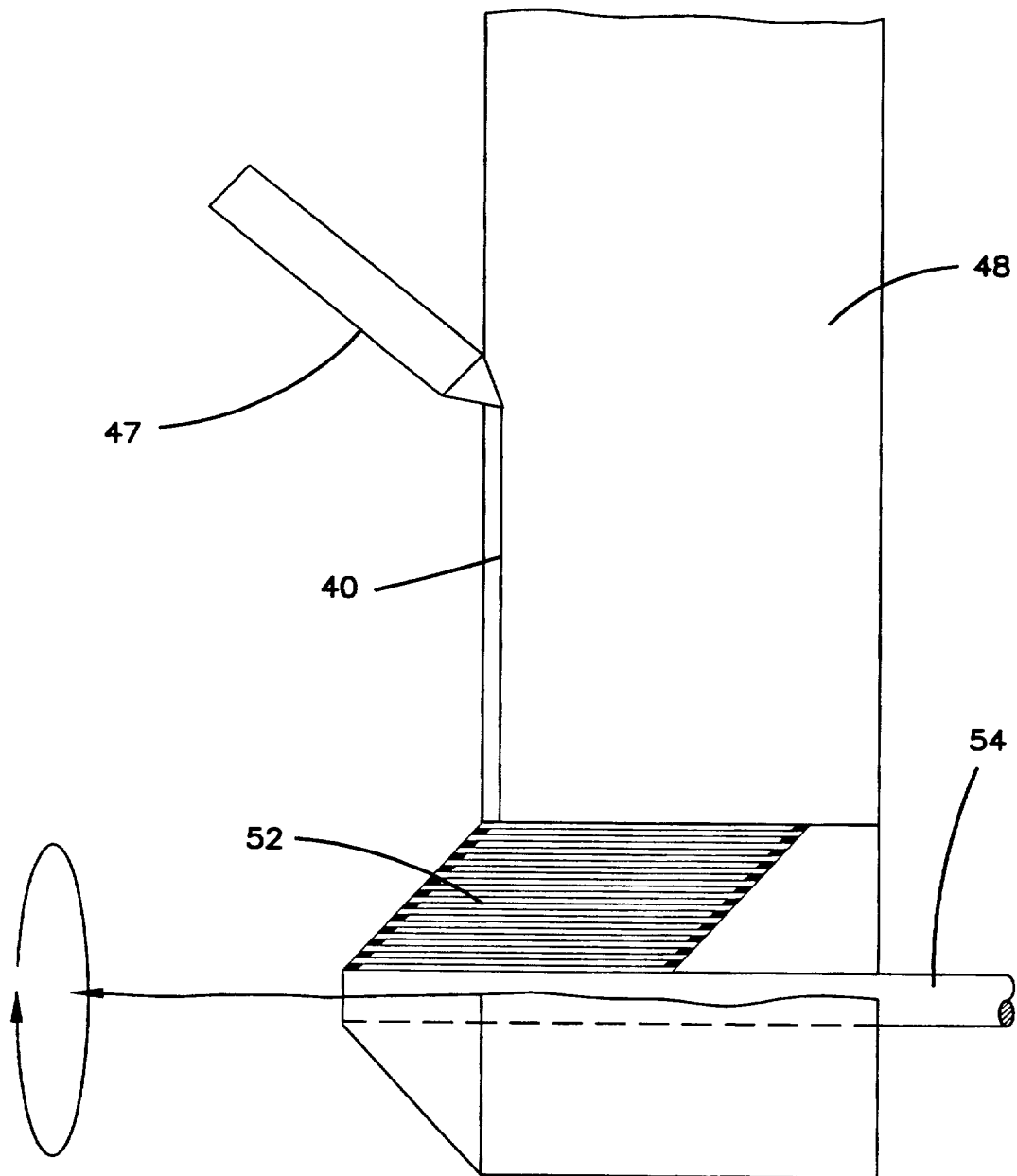


FIG. 7

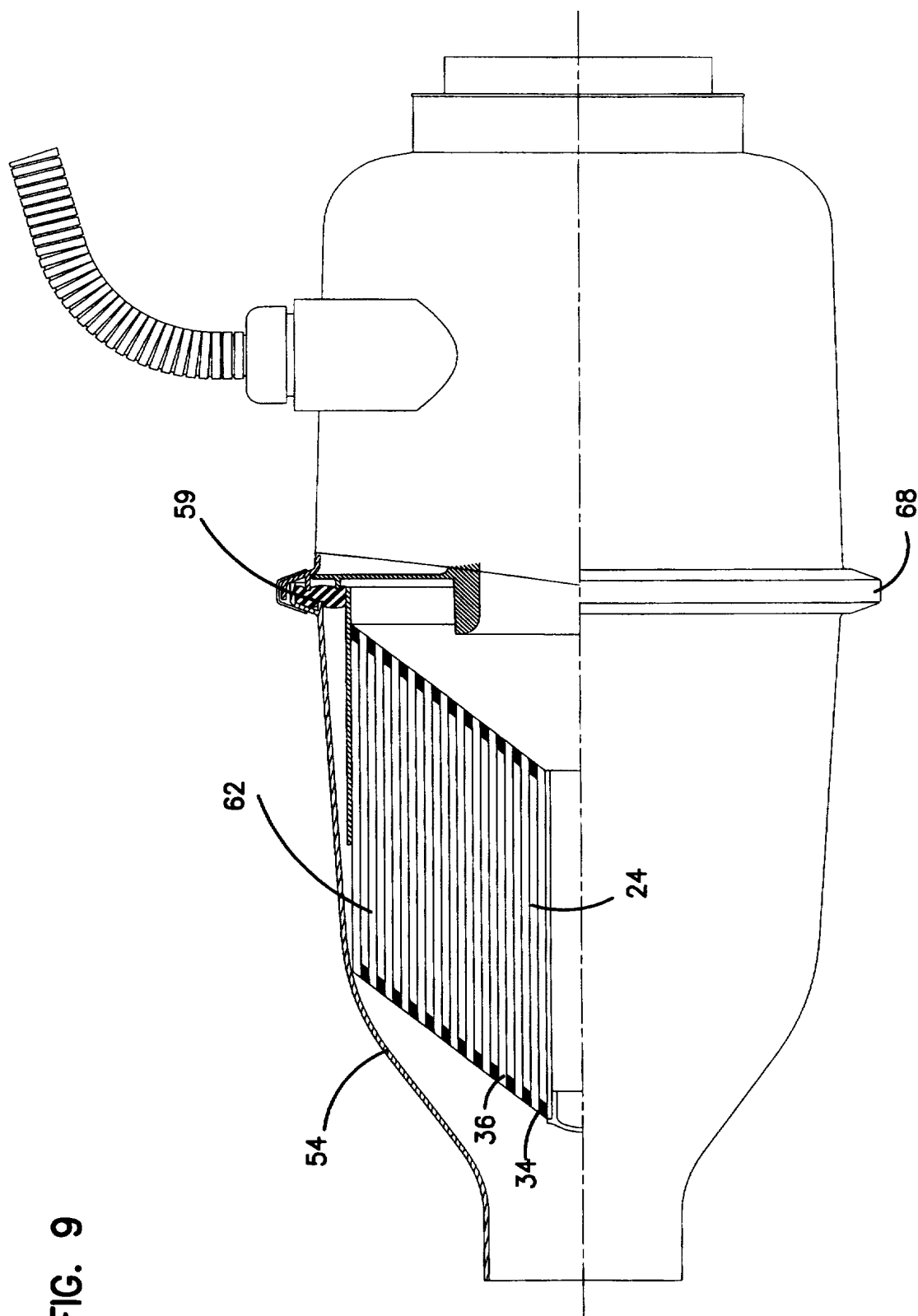


FIG. 9

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FIG. 10

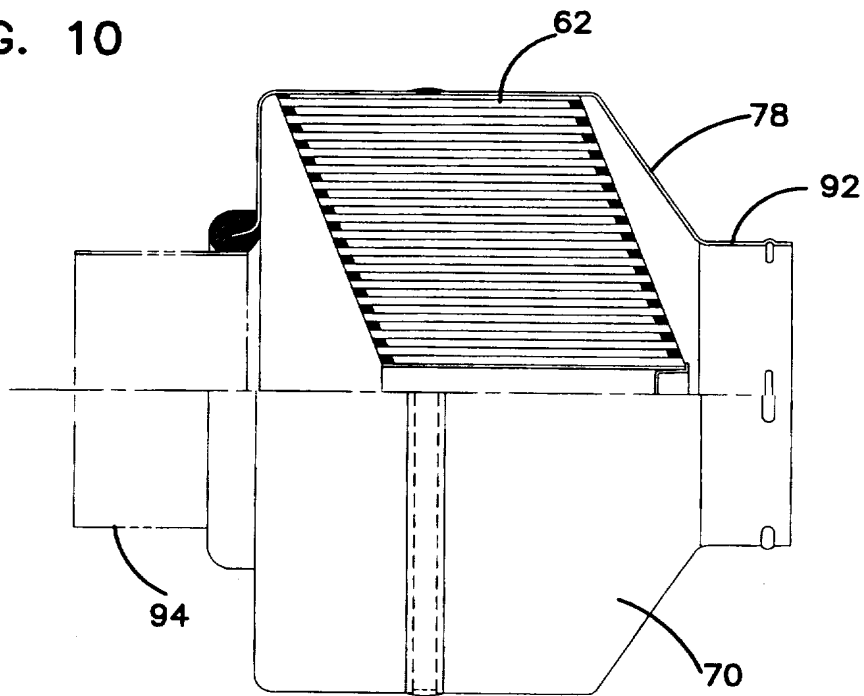
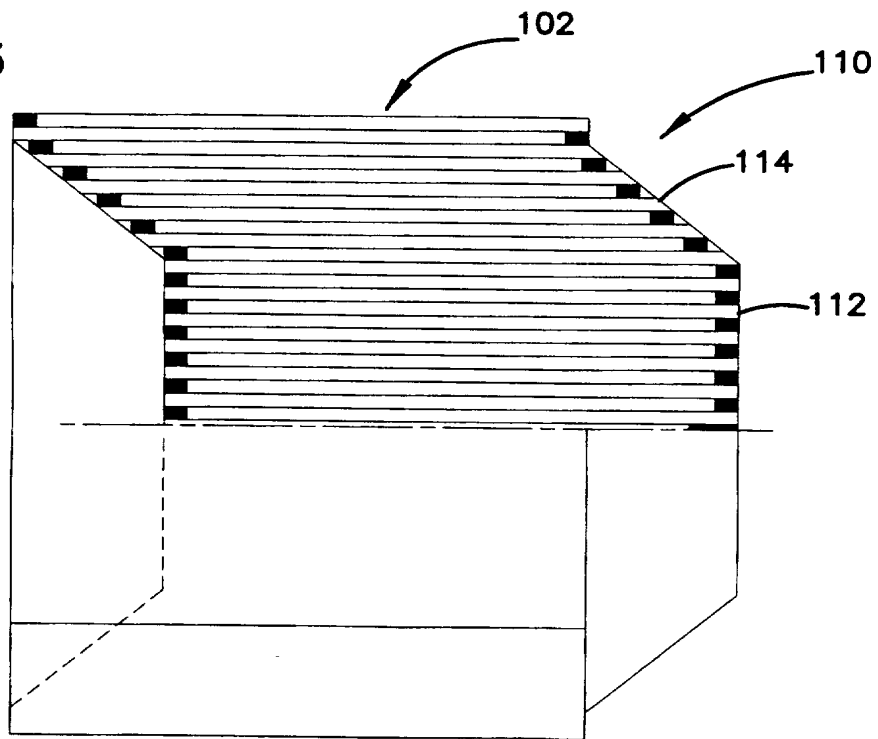
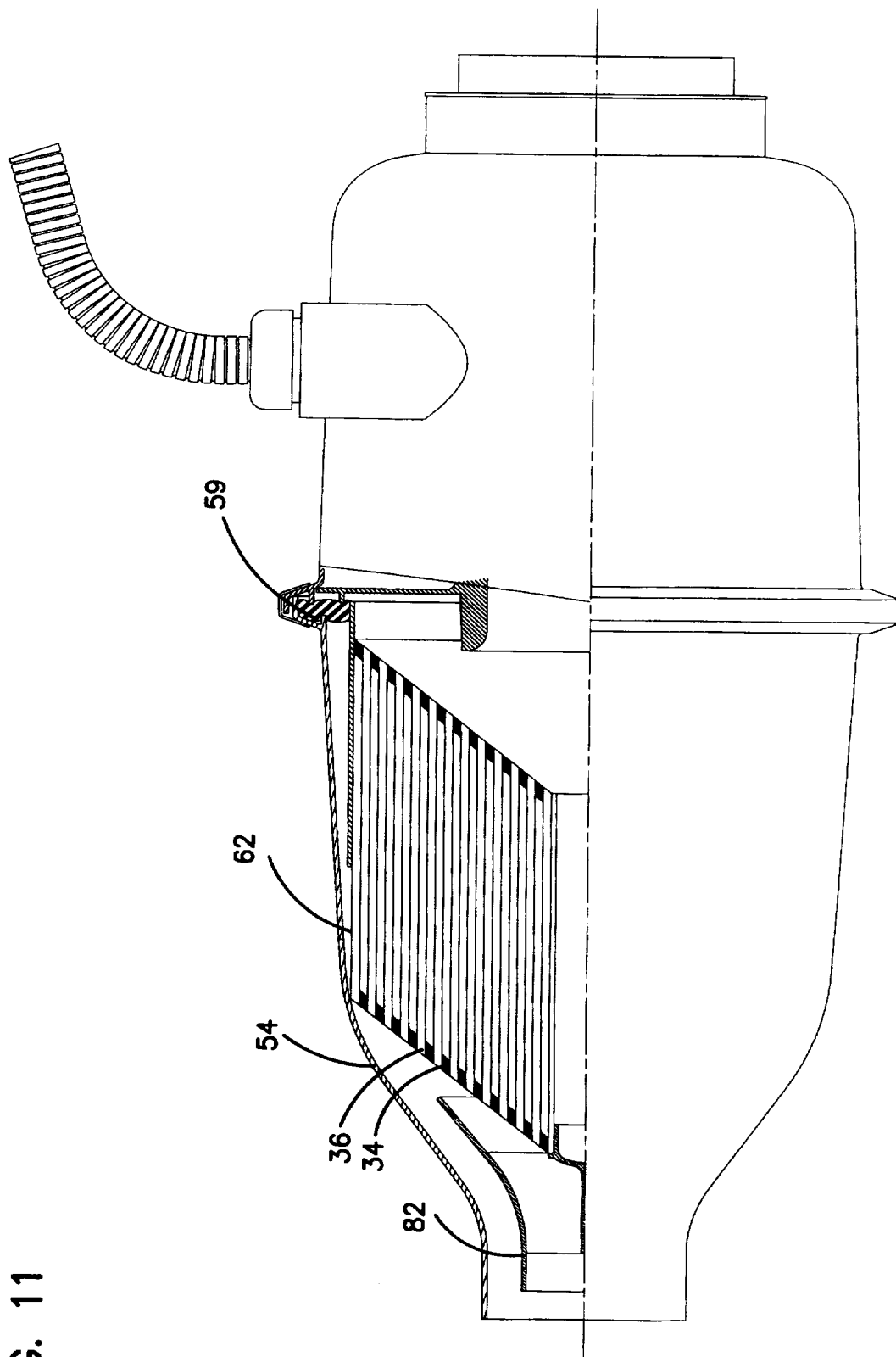


FIG. 13



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FIG. 11



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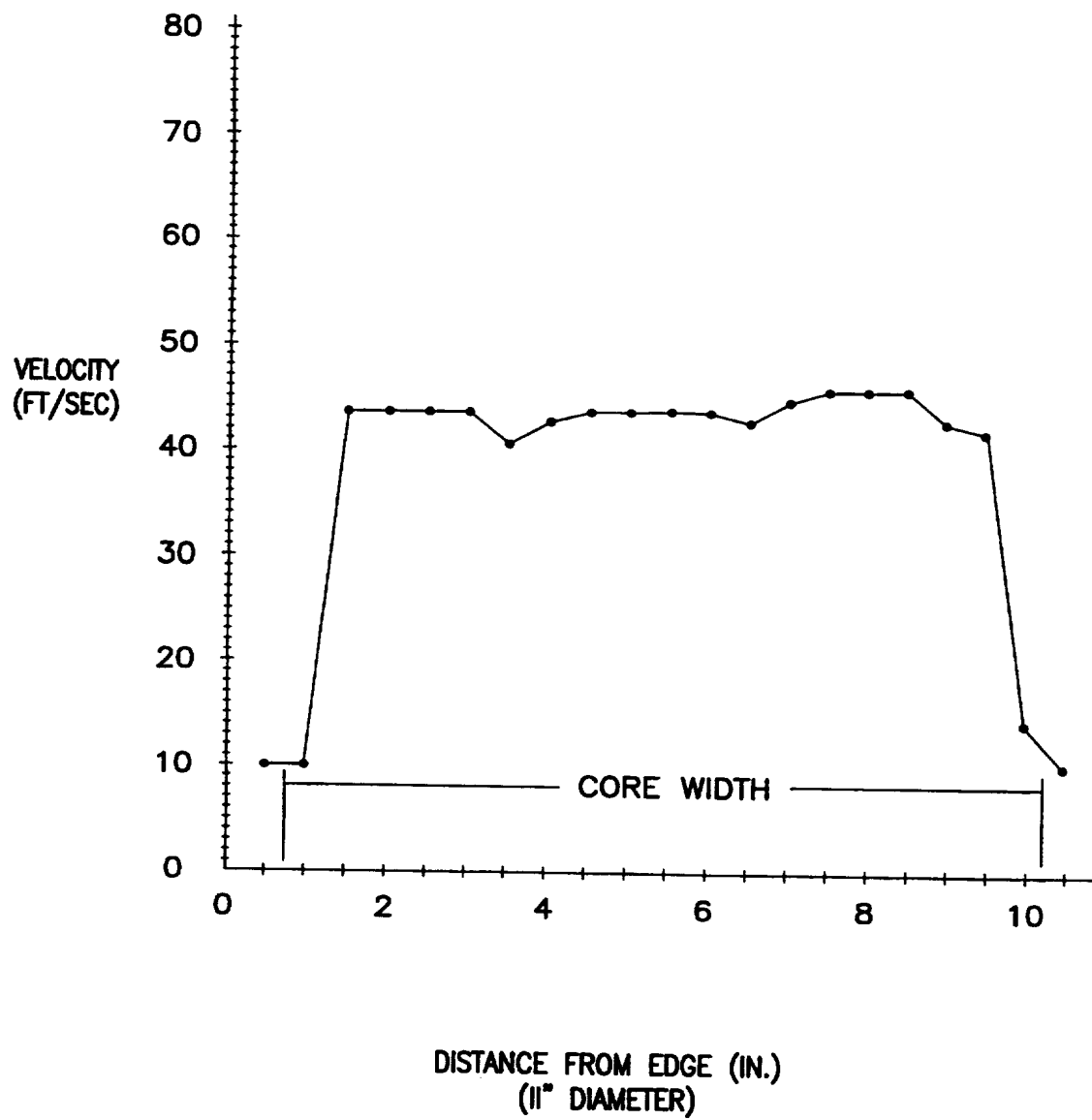


FIG. 12

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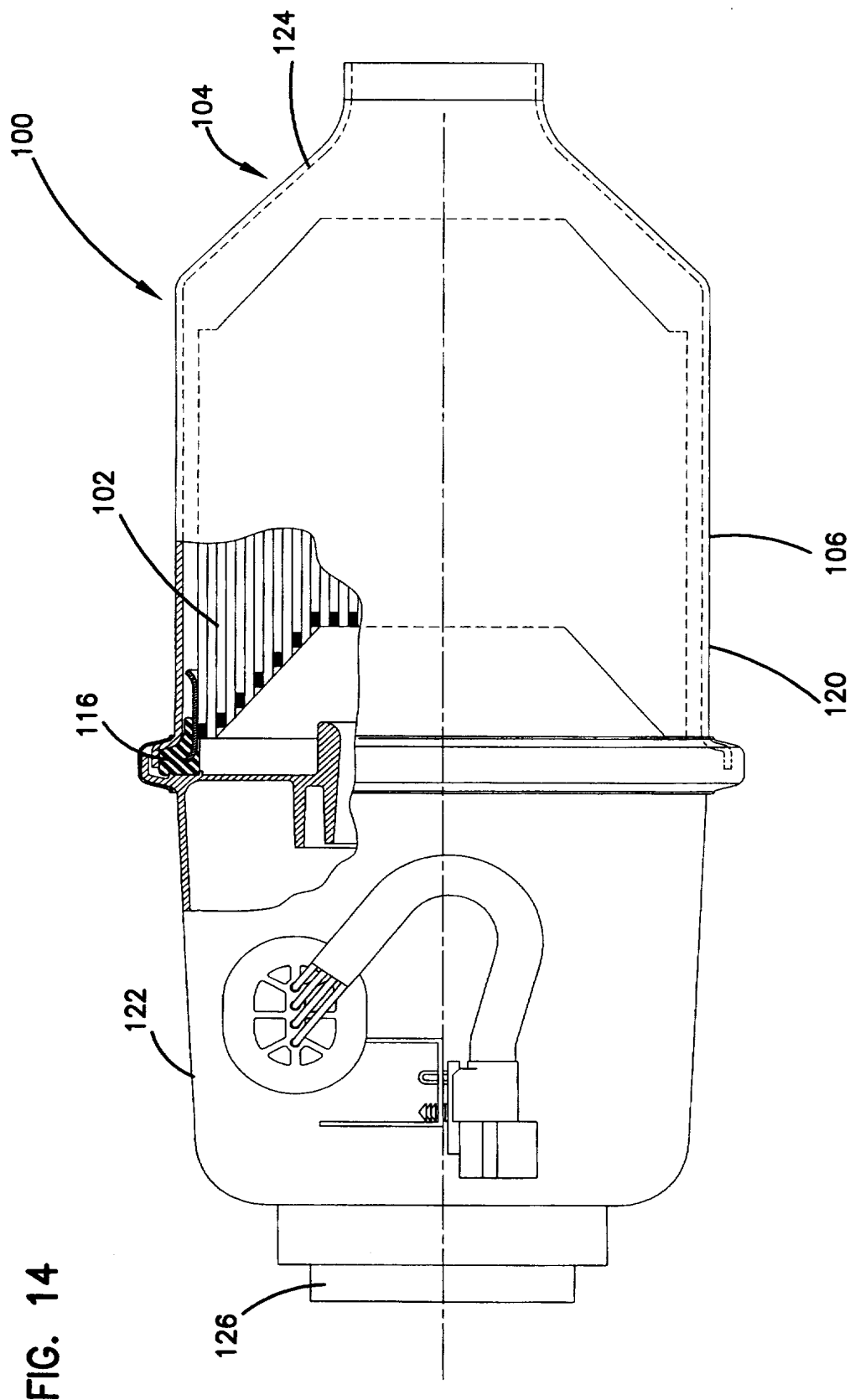


FIG. 14

# INTERNATIONAL SEARCH REPORT

Inter.      nal Application No  
PCT/US 97/06935

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 6    B01D25/24    B01D46/52    F02M35/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 6    B01D    F02M		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 152 513 A (NIPPON DENSO CO) 28 August 1985	24
A	see page 1, line 21 - line 29; figures 2-5 see page 4, line 21 - page 5, line 2 ---	1-13
A	GB 808 154 A (GENERAL MOTORS LIMITED) 28 January 1959 see figure 3 ---	11,12
A	US 2 599 604 A (J. BAUER, R. CURTIS) 10 June 1952 see column 4, line 50 - column 5, line 4; figures 3,4 ---	24
A	EP 0 630 672 A (NIPPON DENSO CO) 28 December 1994 see claims 18,19; figures 1,6 ---	14-24
-/--		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search  <div style="text-align: center; font-size: 1.2em;">1 September 1997</div>		Date of mailing of the international search report  <div style="text-align: center; font-size: 1.2em;">17. 09. 97</div>
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016		Authorized officer  <div style="text-align: center; font-size: 1.2em;">Borello, E</div>

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International Application No

PCT/US 97/06935

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 106 397 A (JAROSZCZYK TADEUSZ ET AL) 21 April 1992 see column 8, line 22 - line 24; figure 2 ---	12
A	US 2 115 577 A (J.H. GOLDMAN) 26 April 1938 see page 26, column 2, line 39 - line 65; figure 5 -----	17

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Information on patent family members

International Application No

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